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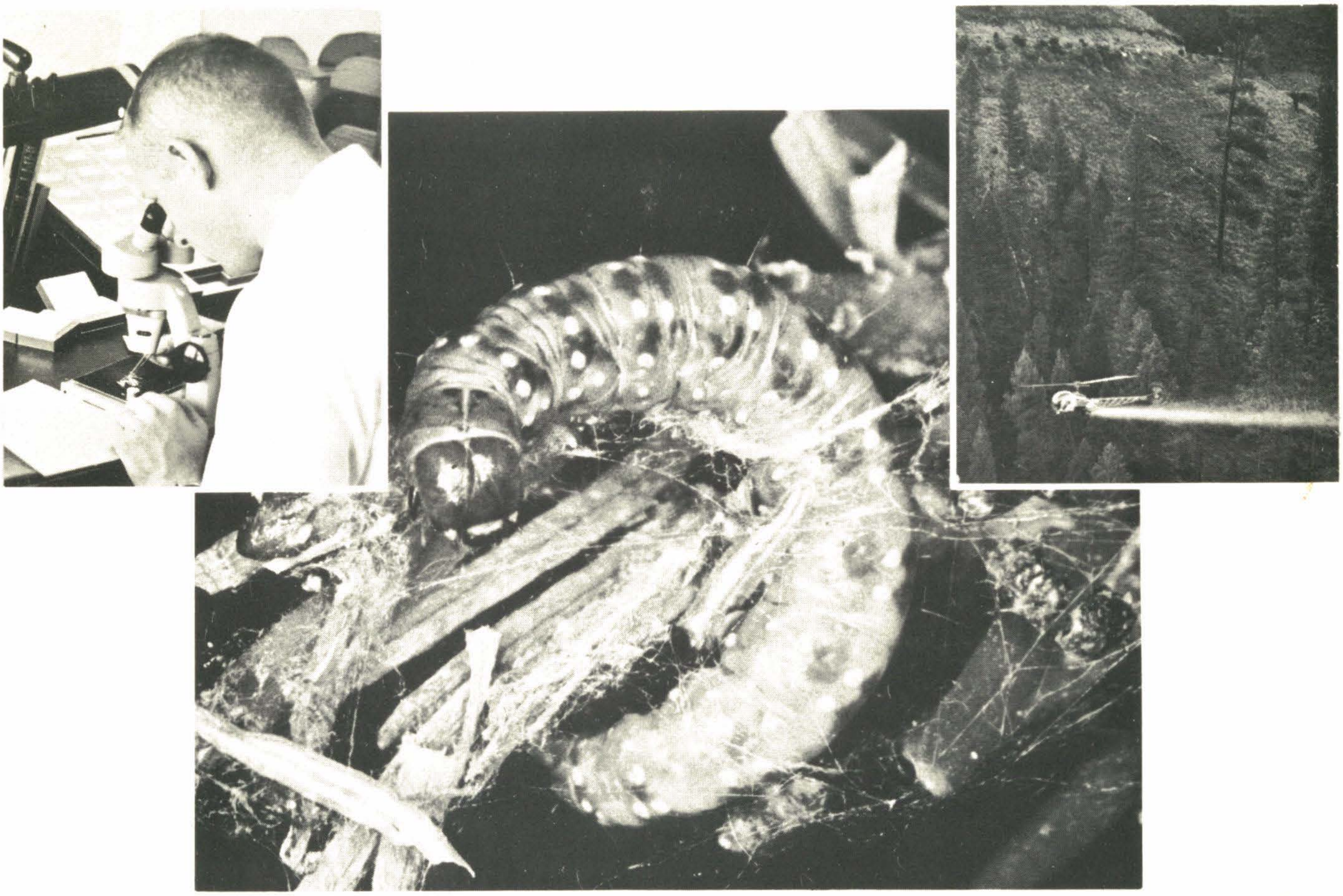
SPRUCE BUDWORM
ZECTRAN
PILOT CONTROL TEST



BITTERROOT NATIONAL FOREST

1966

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE—NORTHERN REGION
DIVISION OF STATE AND PRIVATE FORESTRY

MISSOULA, MONTANA

5200

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SPRUCE BUDWORM ZECTRAN PILOT CONTROL TEST
Bitterroot National Forest
1966

By

Frederick W. Honing, Entomologist
Forest Pest Control Branch

SUMMARY

During July 1966 a pilot test was conducted against spruce budworm on the Bitterroot National Forest, Montana. The carbamate insecticide Zectran (4-Dimethylamino-3, 5-xylyl methylcarbamate) was applied at the rate of 0.15 pound per acre.

Mortality to spruce budworm was 87.2 percent in Trapper Creek and 77.1 percent in Laird Creek. There were no direct effects to fish and wildlife in any of the test areas.

INTRODUCTION

The spruce budworm has defoliated Douglas-fir, true firs, and spruce for over 15 years on the Bitterroot National Forest in Montana.

Previous aerial spray programs have reduced the spruce budworm population sufficiently to increase foliation to approximately the same level as before the infestation. However, reinfestations have required some acreages to be resprayed periodically. Because of this partial success and the fact that persistent chemicals were used against the budworm, the benefits vs. hazards have been questioned.

An effort to find a new nonpersistent and selective insecticide for control of the spruce budworm and a possible substitute for DDT has been underway since 1963 by the Insecticide Evaluation Project (IEP), Pacific Southwest Forest and Range Experiment Station, U.S. Forest Service, Berkeley, California.

The carbamate insecticides generally have shown a high order of biological activity against the spruce budworm. They will also degrade rapidly within living systems. Zectran, a carbamate, is the most toxic chemical tested to date against spruce budworm. Unlike DDT, it holds its high toxicity against all instars. It is about 100 times as toxic to the sixth instar as DDT. Like DDT, it appears to exhibit its greatest biological activity on direct contact with the insect.

Limited field testing of the promising new insecticides against spruce budworm was needed. In the late summer of 1964, a study area was set aside within the West Fork of the Bitterroot River drainage. In 1965, small test areas were set up in the West Fork to conduct field studies with Zectran. Analysis of data showed that 98 percent mortality was obtained in a 335-acre area treated with 0.12 pound of Zectran in six-tenths of a gallon per acre. On the basis of these data, research findings indicated that 95 percent reduction could be obtained with one-tenth of a pound of Zectran per acre.

In early spring of 1966 a pilot test was set up in the East and West Forks of the Bitterroot River, Bitterroot National Forest, Montana. The objectives of this test were twofold:

1. To test a promising new material (0.15 pound of Zectran per acre) against the spruce budworm, Choristoneura fumiferana (Clem.), under normal operating conditions in the field.

2. To allow research scientists to try newer methods for determining spray distribution, budworm mortality, and for measuring effects of Zectran spray application on several forms of wildlife, including small mammals, birds, grouse, fish, and fish habitat.

INFORMATION AND EDUCATION

Through public meetings, various newspaper articles, etc., the public was informed of the reasons for the test.

In early July, during the spray operation, a feature story with pictures appeared in several newspapers in the area, including the Spokesman Review, Spokane, Washington, and the Ravalli Republican, Hamilton, Montana. A similar feature story without pictures was carried in The Missoulian, Missoula, Montana.

PILOT TEST DESCRIPTION

The tests were conducted in several scattered areas. A 3,583-acre area in Trapper Creek on the West Fork of the Bitterroot River and a 1,190-acre replicate area established in Laird Creek on the East Fork Bitterroot River were the principal test locations. Two budworm mortality check areas of approximately 1,000 acres each were located in Violet Creek in the West Fork and in Andrews Creek in the East Fork. A 243-acre area in Mud Creek in the West Fork was used for grouse studies, and approximately 3 miles of Piquett Creek in the West Fork were used for fisheries studies.

The elevation of the spray areas ranged from 4,700 to 6,000 feet, with approximately 80 percent of the area ranging between 4,800 and 5,500 feet.

Except for two small acreages of private land in the main Trapper Creek spray unit, all spray areas are on Forest Service lands.

Replicate Budworm Mortality Spray Area

A 1,190-acre replicate for evaluation of budworm mortality was established in the Laird Creek drainage of the East Fork Bitterroot. No other studies were conducted in this area. This entire area was sprayed with a fixed-wing aircraft.

OPERATIONAL PHASES

FORMULATION

The Zectran concentrate was diluted with a butyl glycol (butyl ether of ethylene glycol = Dowanol) auxiliary solvent at the rate of 1.5 pounds of Zectran to make 1 gallon of solvent. One part of this mixture was then mixed with nine parts of deodorized kerosene (Diabase) for field application. This produced the 0.15 pound of Zectran in 1 gallon of solvent that was to be applied during the spray operation.

Fluorescent particles (solid, insoluble, zinc cadmium sulfide particles, 3.5 microns mass mean diameter, Helecon 2267, U.S. Radium Corporation) blended one-half of 1 percent by weight of a hydrophobic silica additive were used to trace spray distribution. As these solid particles do not penetrate tissues, do not fade on exposure to the elements, and do remain where the drops hit, it is possible to determine the number and size of drops that hit target or non-target insects, plants, or other elements. It had been further determined that the number of particles that are carried by a given spray drop is in proportion to the volume of the drop.

The insecticide, fluorescent particles, and kerosene were formulated and mixed in 1,000-gallon batches as follows:

1. 850 gallons of deodorized kerosene were pumped into the mixing tank and agitation begun.
2. 166.5 pounds of Bentone 34 were sifted very slowly into the mixing unit, making sure that it was added in quantities that would not clump and settle to the bottom of the tank. This critical stage requires constant, rapid agitation at all times.
3. 20 gallons of Ethanol were added to the mixture.
4. 166.5 pounds of fluorescent particles blended one-half of 1 percent by weight of a hydrophobic silica additive.
5. Finally, 100 gallons of Zectran concentrate (Zectran F., 1.5 pounds per gallon) were added.

AIRCRAFT

A Ford tri-motor and a helicopter used on the project were obtained under existing contracts with Johnson's Flying Service, Missoula. The chase plane was furnished by Hamilton Aviation, Inc., Hamilton, Montana, on contract for fire patrol. The aircraft were calibrated for spraying after they arrived on the project.

SPRAY OPERATIONS

Trapper Creek drainage was the main spruce budworm mortality evaluation area. Surveillance studies in this area included three U.S. Fish and Wildlife Service small mammal and bird study plots of 40 acres each, a grouse study plot, and fisheries study plots.

All mixing and loading operations were conducted on the Shook Mountain airstrip (private dirt strip). The airstrip was centrally located and little time was lost in flying to and from spray areas. Just prior to spraying, the areas were checked for unauthorized personnel, and all roads blocked with warning signs and barricades. Stockmen and beekeepers were notified prior to the time spraying was to begin.

U.S. Fish and Wildlife Service

The main Trapper Creek supports a sizable population of native trout and is quite heavily fished. A 1/8-mile strip on each side of Trapper Creek was sprayed with a helicopter to minimize drift into the stream and minimize damage to fish or aquatic insects.

A 3-mile stretch in Piquett Creek, which enters into the West Fork Bitterroot River, was set aside as a special fisheries study area for the U.S. Fish and Wildlife Service. All spray operations in this area were made from directly over the stream by a helicopter at an elevation of about 250 feet. The lower 1 mile was sprayed with three consecutive applications of Zectran, while the upper 1½ miles were sprayed only once. Fish and Wildlife biologists stated that there were no apparent effects to fish populations, and they observed only a slight increase in the number of drifting aquatic insects. Boulder Creek, which enters the West Fork Bitterroot upstream from Piquett Creek, was used as a check stream for fisheries studies.

Fish and wildlife study data will be reported separately.

Although Trapper Creek was not deliberately sprayed, insect drift in the stream was nearly as great as in Piquett Creek; however, there didn't appear to be any measurable effect on aquatic insects in Trapper Creek.

Montana Fish and Game Department

A 243-acre grouse study plot was set up in Mud Creek drainage of the West Fork by the Montana State Fish and Game Department. This plot was sprayed by helicopter on June 25 with five consecutive applications of Zectran formulation. One Creek and Two Creek were used as a check area for grouse studies. Preliminary results indicate no apparent direct effects to grouse during or after spraying. In general, observations show no apparent direct effects from the spray to birds and small mammals in any of the test areas. A complete report is being prepared by the Montana Fish and Game Department.

SAFETY

Due to the high, acute oral toxicity of Zectran, special precautions were taken to protect project personnel handling the insecticide from possible accident. During handling of the concentrate or diluted material, protective gloves and clothing were required. The insecticide had a very adverse effect on rubberized fabric; consequently, special chemical-resistant clothing was obtained and used. Persons working directly with the material were not allowed to eat or smoke unless they thoroughly washed hands and face with soap and water. Blood cholinesterase checks were made at the U.S. Public Health Service, Rocky Mountain Laboratory, Hamilton, Montana, as a routine safety measure on the spray pilots, mechanics, and all personnel formulating or handling the spray. Blood samples for the tests were taken before, during, and immediately after the spray project completion.

Pilots of the Ford tri-motor complained that insecticide fumes were particularly bad in aircraft during spraying. However, it was not determined if the fumes were actually from the insecticide or from the gasoline power unit used for pressure in the spray equipment inside the aircraft. Subsequently, masks with special filters were provided to be worn by all pilots at all times during spraying.

Blood tests showed that cholinesterase levels were not significantly different from normal values.

A night watchman was used to prevent unauthorized personnel from coming in contact with the insecticide.

There were no accidents or injuries during the course of the entire project.

COMMUNICATIONS

A six-unit radio net was obtained from the Division of Fire Control. Weather information was relayed at half-hour intervals beginning at 3:30 a.m. to the airbase. Montana Fish and Game Department and Pacific Southwest Forest and Range Experiment Station operated on separate wave lengths; consequently, three different radio systems were used. The administrative officer and project entomologist acted as radio operators at the base camp.

ENTOMOLOGICAL PHASES

Development Sampling

Some 8,682 spruce budworm larvae were collected during daily sampling for the purpose of determining the proper time for spraying. Sampling began on June 14, about 2 weeks after the second instar larvae were found to have broken hibernation. Sampling was continued until June 26, at which time the areas were released for spraying.

Samples were carefully collected at midcrown using pole pruners with an attached collecting bag. They were labeled and delivered to a central "counting room." Women counters carefully examined each foliage sample, dissected all unopened buds, collected all budworm larvae, and placed them in alcohol. Larvae were later put into Petri dishes and separated according to their instar classification.

Plots were released for spraying when daily collections showed approximately 90 percent in the fourth and fifth instars, with not more than 5 percent in the third and sixth instars.

Prespray Sampling

Single-tree plots selected as being representative were established throughout the test and check areas. Sample trees were plotted on maps, marked, and tagged with an identification number. There were 50 plots in each test area and 30 plots in each check area. All samples were taken at midcrown with pole pruners. Four 15-inch branch samples were taken from each plot 1 or 2 days prior to spray application. A total of 640 samples were taken. Women counters measured and recorded the foliated length and width of each sample branch and counted the number of buds and budworms (form 59-5240-3).

Postspray Sampling

Postspray sampling began 7 days after spraying. Sixteen 15-inch branch samples were taken at midcrown from each tree sampled during prespray sample collections. A total of 2,560 samples were collected. The counters measured and recorded the foliated length and width of each sample and counted the number of buds and budworms. Sampling is summarized in table 1.

Table 1.--Summary of samples taken and number of insects found

Area	Development samples			Prespray samples		Postspray samples	
	No. of samples	No. of budworms	Other insects	No. of samples	No. of larvae	No. of samples	No. of larvae
Trapper Creek	640	3,053	103	200	567	800	93.7
Laird Creek	436	2,084	106	200	996	800	141.7
Pine and Violet Creeks	328	2,042	152	120	603	480	333.2
Andrews Creek	296	1,503	50	120	540	480	191.8
TOTAL	1,700	8,682	411	640	2,706	2,560	760.4

Total samples taken = 4,900

Total larvae collected = 12,148

Total days sampling development = 10 (6 men)

Total days prespray sample = 3 (4 men)

Total days postspray sample = 4 (6 men)

Project started with development sampling on June 14, 1966.

Project ended with postspray sampling on July 12, 1966.

RESULTS

Results of budworm mortality are shown in table 2.

Table 2.--Mortality estimates in percentages and without Abbott's correction

Area	Bud-based mortality estimate	S.E.[1]	Area-based mortality estimate	S.E.
Trapper Creek	87.2	1.6	82.3	2.2
Laird Creek	77.1	3.7	84.5	3.0
Violet Creek (check area)	43.9	3.4	46.0	3.5
Andrews Creek (check area)	48.5	4.8	46.0	7.8

[1] Standard error.

These data were analyzed by Gerald S. Walton, statistician, Insecticide Evaluation Project, Pacific Southwest Forest and Range Experiment Station. From Walton's past experience (personal communication), larvae-area and larvae-bud correlations, and biological considerations, the bud-based estimate is probably the better.

The difference in mortality data between Laird Creek and Trapper Creek is not completely understood. Walton's analysis indicates that, in both spray areas, the number of buds per unit branch surface changed between the pre- and post-spray sampling periods, and that this change was not consistent. For Laird Creek, the number of buds per unit area decreased over the sampling period and for Trapper Creek, it increased. The problem probably lies in size of branch sample. However, sample collections were taken by the same individuals during the entire sampling period.

ASSESSMENT OF SPRAY DISTRIBUTION

Four red Kromekote spray cards in wire holders were placed on the uphill, downhill, and remaining two sides of each sample tree. Cards were placed in clear, open spots that were not shaded from falling spray droplets. Cards and cardholders were provided by the Insecticide Evaluation Project (PSW). Cards were recovered as soon as an area had been sprayed. New cards were put out on all spray plots at the end of each day until spraying was finished.

Due to the scattered, small rain showers in the spray areas, cards were placed just prior to spraying. This meant that the card layers had to be on the job putting out the cards at 1 a.m. Spraying generally started at about 4:30 a.m.

Counts of droplets on spray deposit cards were taken from the center square centimeter using a binocular microscope and 20x magnification. Counts averaged 50.38 ± 34.70 droplets per square centimeter and ranged between 6.0 to 133.0 droplets per square centimeter. Droplet maximum was 360 microns and mmd was 164 microns. All counts were made by PSW personnel.

A regression analysis on mortality versus spray deposit was nonsignificant. However, considerable difficulty was encountered in mixing the fluorescent particles. The particles apparently did not suspend uniformly throughout the spray mixture and settled, in spite of consistent agitation. Small clumps of particles clogged the spray nozzles during the operation and further complicated the results. These droplets easily smear on the deposit cards and counts may have been individual particles from droplets or from smears of droplets.

PROJECT PERSONNEL

Project Supervisor	John Grove	Bitterroot NF
Project Entomologist	Fred Honing	Pest Control Branch, S&PF, RO
Assistant Project Entomologist	Jerald E. Dewey	Pest Control Branch, S&PF, RO
Coordinator	Robert Hensler	Custer NF
Airbase Supervisor	Richard Venable	Bitterroot NF
Air Officer	Robert Mock	Division of Fire Control, RO
Administrative Officer	Dick Bolstad	Bitterroot NF
Formulator and Mixer Operator	William Paul	Coeur d'Alene NF
Loader	1 man	Bitterroot NF
Biological Checkers	6 men	Bitterroot NF
Women Counters	5 local women	Hamilton-Darby, Montana, area

Principal Investigators of Cooperative Agencies

U.S. Fish and Wildlife Service

Fisheries studies	Dr. Richard J. Graham William R. Gould
Wildlife studies (birds and small mammals)	Edward L. Flickinger Merle L. Richmond Richard E. Pillmore

Montana State Fish and Game Department

Grouse study	Dr. Tom Mussehl Ralph Boland

Insecticide Evaluation Project, PSW, Berkeley, California

Project leader	Dr. Arthur Moore
Entomologists	Dr. Carrol Williams Paul Buffam
Meteorologist	Gerard Demarrais
Chemist	Raymond Miscus
Forestry technicians	Hubert Meyer Christopher Duckles

Missoula Equipment Development

Entomologist	Donn Cahill
Mechanical engineer	Anthony Jasumback

APPENDIX

ZECTRAN PROJECT COSTS
F.Y. 1966-67

	604		704	
AIRCRAFT				
Helicopter	$1,341.83		0	
Ford Tri-motor	1,282.54		0	
Observation plane	578.17		0	
Total Aircraft		$3,202.54		0
INSECTICIDES & CHEMICALS				
Zectran	13,263.00		0	
Fluorescent particles & three analyses	11,990.23		0	
Kerosene & transportation	2,230.80		0	
Kerosene storage	184.62		0	
Ethyl alcohol	280.01		0	
Denatured alcohol	45.20		0	
Bentone	911.90		0	
Total Insect. & Chem.		28,905.76		0
PERSONNEL				
Salaries	7,947.79		$5,659.51	
Per diem	570.78		295.46	
Total Personnel		8,518.57		$5,954.97
MISCELLANEOUS				
Mileage (WCF)	1,213.62		640.13	
Vehicle rental	989.48		475.94	
Telephone	112.70		74.50	
Photography	705.98		28.65	
Aerial photos	108.65		0	
Miscellaneous supplies	585.49		125.95	
Total Miscellaneous		3,715.92		1,345.17
FOREST CHARGE				
909 (S.O.)		1,498.00		975.00
TOTAL COSTS		$45,840.79		$8,275.14
GRAND TOTAL			$54,115.93	

SPRAY AREA DATA FORM
(Reference FSM 5242)

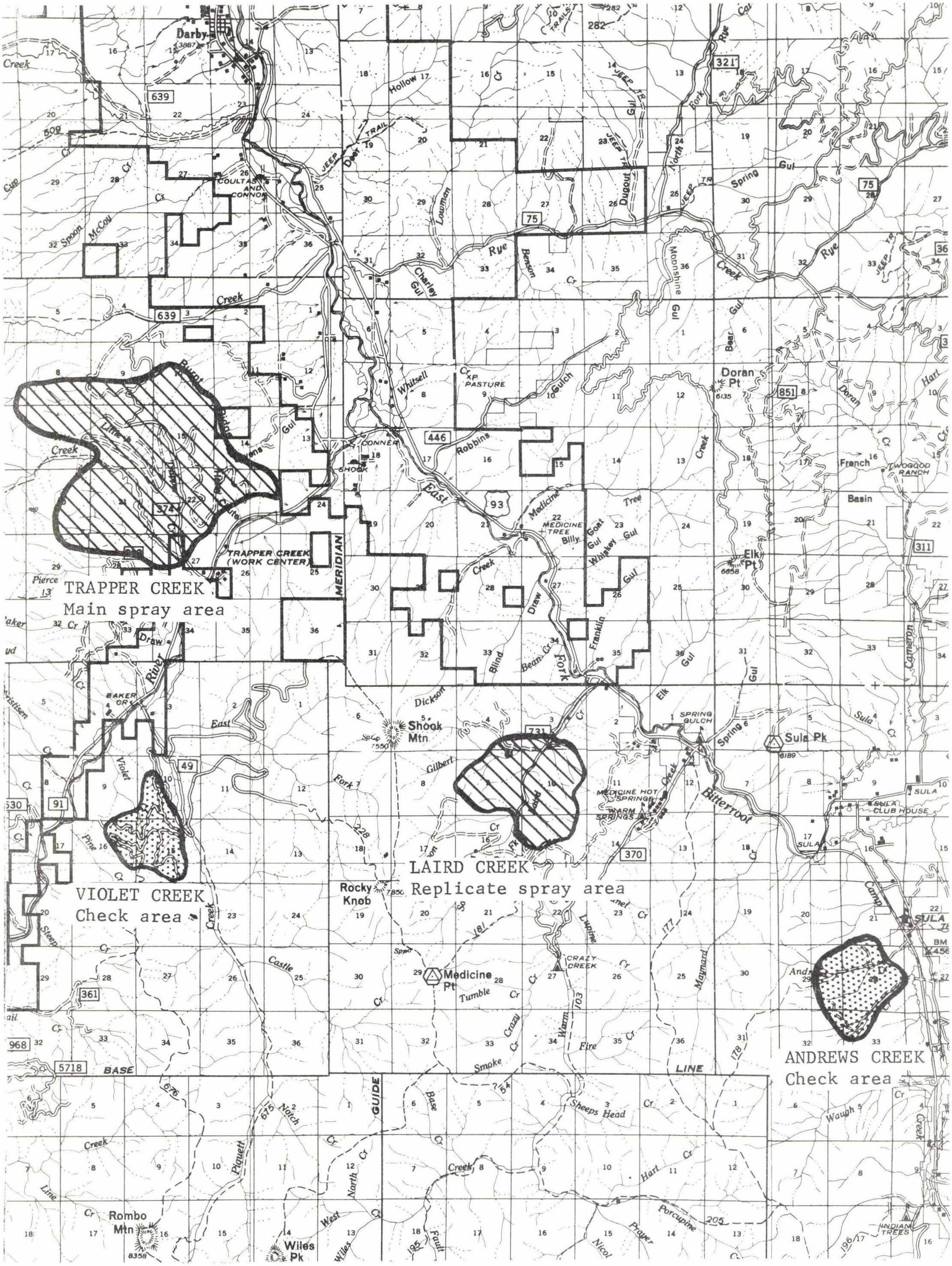
Region
1

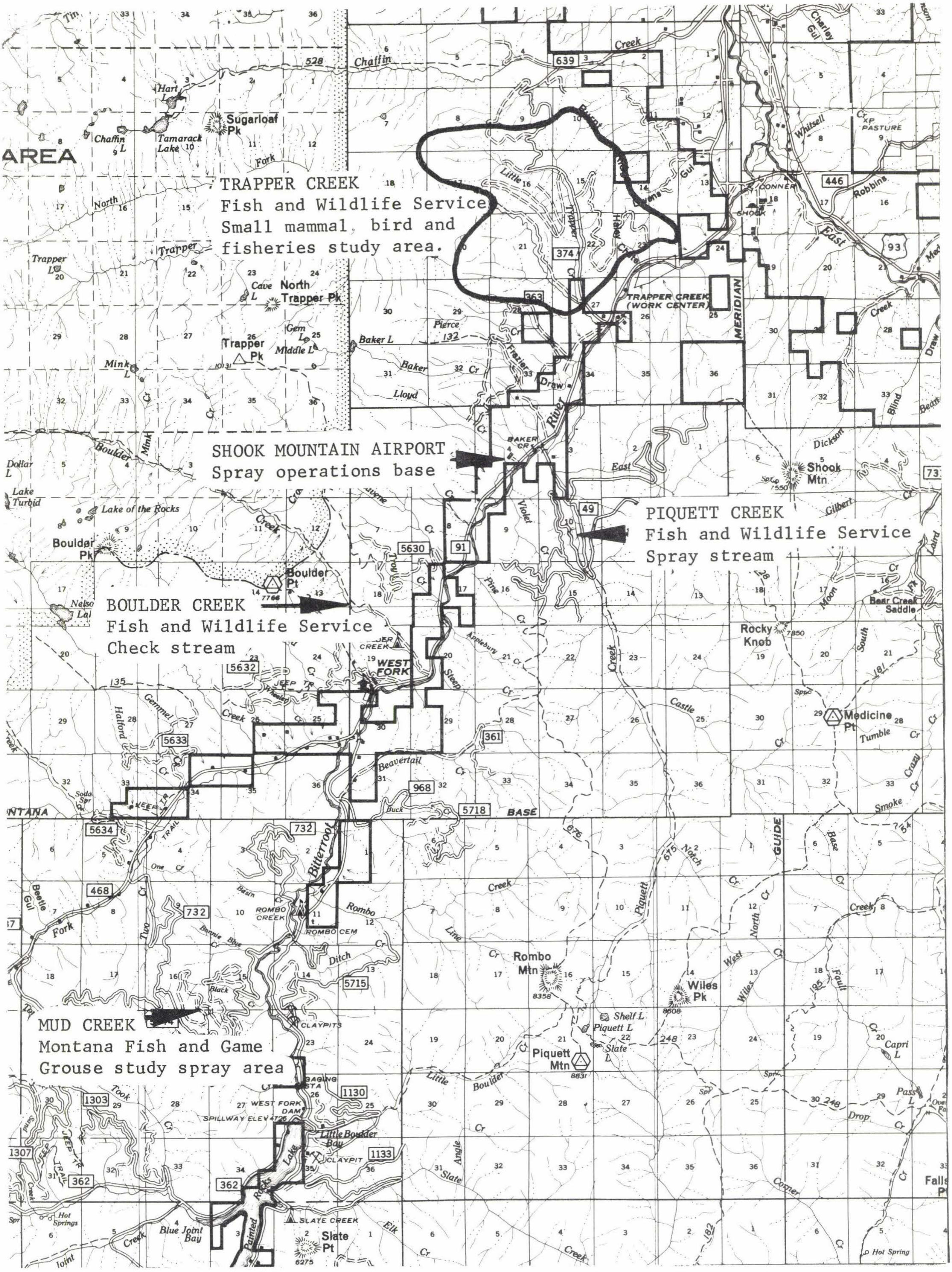
Tree No.

Checked by

Date

Branch		Length	Width	Bud count	Budworm count
Prespray	1				
	2				
	3				
	4				
Postspray	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
	10				
	11				
	12				
	13				
	14				
	15				
	16				


TRAPPER CREEK
Main spray area
LAIRD CREEK
Replicate spray area
VIOLET CREEK
Check area
ANDREWS CREEK
Check area
Darby
COULTAS AND CONNOR
TRAPPER CREEK (WORK CENTER)
CONNER
SHOOK
MERIDIAN
MEDICINE TREE
Shook Mtn
Rocky Knob
Medicine Pt
CRAZY CREEK
MEDICINE HOT SPRINGS
WARM SPRINGS
SPRING GULCH
Sula Pk
SULA
SULA CLUB HOUSE
Doran Pt
Elk Pt
TWOGOOD RANCH
French Basin
BAKER CR
Rombo Mtn
Wiles Pk
INDIAN TREES
BASE LINE
GUIDE
Bitterroot
East Fork
Rye Creek
93
75
446
639
731


TRAPPER CREEK
Fish and Wildlife Service
Small mammal, bird and fisheries study area.

SHOOK MOUNTAIN AIRPORT
Spray operations base

PIQUETT CREEK
Fish and Wildlife Service
Spray stream

BOULDER CREEK
Fish and Wildlife Service
Check stream

MUD CREEK
Montana Fish and Game
Grouse study spray area

AREA
Chaffin
528
Hart L
Sugarloaf Pk
Chaffin L
Tamarack Lake
North Fork
Trapper
Trapper L
Cave L
North Trapper Pk
Gem L
Middle L
Trapper Pk
Mink L
Baker L
Pierce
132
Baker Cr
Lloyd
Little Trapper
Haley Cr
Owens Gul
Creek
639
374
363
TRAPPER CREEK (WORK CENTER)
MERIDIAN
CONNER
SHOOK
446
Robbins
East
93
Whitsell
Charley Gul
Cr XP PASTURE
Frazier Draw
River
BAKER CR
Boulder
Dollar L
Lake Turbid
Lake of the Rocks
Boulder Pk
Boulder Pt
7766
Nelson Lake
East
Shook Mtn
7550
Dickson
Gilbert
Violet
49
91
5630
Pine
Troy
Applebury
Steen
West Fork
Boulder Creek
5632
135
Gemmel
Halford
Jeep Tr
Wheeler
Creek
5633
361
Beavertail
968
5718
BASE
Buck
Soda Spr
5634
MONTANA
Jeep Trail
Castle
Creek
Rocky Knob
7850
Moon
Bear Creek Saddle
South
181
Medicine Pt
Tumble
Crazy
Smoke
Laird
Blind
Draw
Bean
732
Bitterroot
Rombo
Rombo Creek
Rombo Cem
468
Beetle Gul
Fork
Two
One Cr
Basin
Bonnie Blue
732
Ditch
5715
Black
Claypits
676
675 Notch
Piquett
Line
Creek
GUIDE
Base
North
Rombo Mtn
8358
Wiles Pk
8608
West Wiles
Fault
195
Creek
Shelf L
Piquett L
Slate L
248
Piquett Mtn
8831
Capri L
Little Boulder
Pass L
Drop
Gaging Sta
West Fork Dam
Spillway Elev 4726
1130
1303
Took
1307
Jeep Trail
362
Little Boulder Bay
Claypit
1133
Angle
Slate
Corner
Painted Rocks Lake
Hot Springs
Blue Joint Bay
Joint
Slate Creek
Slate Pt
6275
Elk
Creek
182
Hot Spring
Falls Pt